**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**5-1.1 Identify questions suitable for generating a hypothesis.**
**Taxonomy Level:** 1.1-C Remember Procedural Knowledge

**Previous/Future knowledge**: In 3rd grade (3-1.3), students generated questions such as "what if?" or "how?" about objects, organisms, and events in the environment and use those questions to conduct a simple scientific investigation. In 4th grade (4-1.3), students summarized the characteristics of a simple scientific investigation that represent a fair test (including asking a question that identifies a problem). Students have not been introduced to the concept of hypothesis prior to this grade. In 7th grade (7-1.2), students will generate questions that can be answered through scientific investigation. In 8th grade (8-1.4), students will generate questions for further study on the basis of prior investigations.

**It is essential for students to** know that only *testable questions*, which are used to test one variable, are suitable for scientific investigations. The question should include the relationship between the *independent* (manipulated) variable and *dependent* (responding) variable. For example, the following are testable questions:

- How does the amount of space affect the population of fish in a pond?
  - The independent (manipulated) variable is size of the pond.
  - The dependent (responding) variable is the population of fish in the pond.
- What is the effect of slope of the land on the amount of soil erosion?
  - The independent (manipulated) variable is the slope of the land.
  - The dependent (responding) variable is the amount of soil erosion.
- How does stirring affect the rate that salt dissolves in water?
  - The independent (manipulated) variable is the stirring.
  - The dependent (responding) variable is the time to dissolve.

**It is also essential for students to** know that a prediction about the relationship between variables is formed from the testable question. This prediction is called a *hypothesis*.

- All controlled investigations should have a hypothesis.
- A hypothesis can be stated positively or negatively. For example,
  - The smaller the pond, the smaller the population of fish. (negative statement)
  - The greater the slope of the land, the more soil erosion will be observed. (positive statement)
  - The faster the stirring, the shorter amount of time it will take to dissolve the salt. (positive statement)
- A hypothesis can also be stated as a cause-and-effect ("If…then,…") statement. For example, "If there is more food available, then the population of fish will increase."
- The experiment is conducted to support or not support a hypothesis. If the hypothesis is not supported by the experiment, it can still be used to help rule out some other ideas.

NOTE TO TEACHER: In 4th grade (4-1.3), students generated predictions to the testable questions. In 5th grade, students will continue to generating these predictions, but use the term hypothesis.

**It is not essential for students to** conduct an investigation for every question they generate or generate questions based on prior investigations.

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**Assessment Guidelines:**
The objective of this indicator is to *identify* questions suitable for generating a hypothesis; therefore, the primary focus of assessment should be to recognize a question that leads to a hypothesis. However, appropriate assessments should also require students to *recognize* an appropriate hypothesis from a testable question or investigation; *recognize* that a testable question should have a manipulated and responding variable; or *identify* the manipulated and responding variables in a question.

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**5-1.2 Identify independent (manipulated), dependent (responding), and controlled variables in an experiment.**
**Taxonomy Level:** 1.1-B Remember Conceptual Knowledge

**Previous/Future knowledge**: In 4th grade (4-1.5), students recognized the correct placement of variables on a line graph. In 7th grade (7-1.5), students will explain the relationship between independent and dependent variables in controlled a scientific investigation through the use of appropriate graphs, tables, and charts.

**It is essential for students to** know that in an experiment there are three types of variables.
- The manipulated variable (changed or tested in the experiment) is also called the *independent variable*.
- The variables that are kept the same, or unchanged, in the experiment are called the *controlled variables*.
- The responding variable (the result of, or response to, the manipulated variable) is also called the *dependent variable*.

For example, a student conducts an experiment to test whether changing the surface of the floor will increase the distance a toy car will roll. The student uses carpet, rubber mat, and the floor. When the car is pushed with the same amount of force on each surface, the student finds that it rolls farther on the floor than the carpet or rubber mat. The independent (manipulated) variable is the surface of the floor. The controlled variables are the size of the carpet and rubber mat, the same toy car, and the force with which the car is pushed. The dependent (responding) variable is the distance the car rolled.

NOTE TO TEACHER: Students should be using both terms independent (manipulated) and dependent (responding) when describing variables.

**Assessment Guidelines:**
The objective of this indicator is to *identify* variables in an experiment; therefore, the primary focus of assessment should be to recognize a variable as independent (manipulated), dependent (responding), and controlled in an experiment.

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**5-1.3 Plan and conduct controlled scientific investigations, manipulating one variable at a time.**
**Taxonomy Level:** 6.2 and 3.1 Create and Apply Conceptual Knowledge

**Previous/Future knowledge**: In 1st grade (1-1.3), students carried out simple scientific investigations when given clear directions. In 2nd grade (2-1.1), students carried out simple scientific investigations to answer questions about familiar objects and events. In 4th grade, students summarized the characteristics of a simple scientific investigation that represent a fair test (including a question that identifies the problem, a prediction that indicates a possible outcome, a process that tests one manipulated variable at a time, and results that are communicated and explained) (4-1.3) and constructed and interpreted diagrams, tables, and graphs made from recorded measurements and observations (4-1.6). In 7th grade, students will explain the reasons for testing one independent variable at a time in a controlled scientific investigation (7-1.3) and will explain the importance that repeated trials and a well-chosen sample size have with regard to the validity of a controlled scientific investigation (7-1.4). In 8th grade, students will design a controlled scientific investigation (8-1.1) and will explain the importance of and requirements for replication of scientific investigations (8-1.5).

**It is essential for students to** know that a *controlled scientific investigation* determines the effect of an independent variable in an experiment, when all other variables are controlled. Every controlled scientific investigation provides information. This information is called *data*. Data includes both scientific observations and inferences.

- A *scientific observation* is gained by carefully identifying and describing properties using the five senses or scientific tools and can be classified as *quantitative* or *qualitative*.
  - Quantitative observations are observations that use numbers (amounts) or measurements (including the unit label) or observations that make relative comparisons, such as more than, all, less than, few, or none.
  - Qualitative observations are observations that are made using only the senses and refer to specific properties.
- An *inference* is an explanation or interpretation of an observation based on prior experiences or supported by observations made in the investigation. They are not final explanations of the observation. There may be several logical inferences for a given observation. There is no way to be sure which inference best explains the observation without further investigation.

In order to design a *controlled scientific investigation* some or all of the following steps should be included:

- Identify a testable question (tests one variable) that can be investigated
- Research information about the topic
- State the hypothesis as a predicted answer to the question, what may be the possible outcome of the investigation
- Design an experiment to test the hypothesis, controlling all variables except the independent (manipulated) variable
  - Plan for independent (manipulated) and dependent (responding) variables
  - Plan for factors that should be held constant (controlled variables)
  - List the materials needed to conduct the experiment
  - List the procedures to be followed
  - Plan for recording, organizing and analyzing data

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

- Conduct the experiment and record data (observations) in tables, graphs, or charts
- Analyze the data in the tables, graphs, or charts to figure out what the data means (describe the relationship between the variables)
- Compare the results to the hypothesis and write a conclusion that will support or not support the hypothesis based on the recorded data
- Communicate the results to others

**It is essential for students to** conduct a controlled scientific investigation after planning the experimental design.

- Appropriate tools should be selected and used.
- Appropriate safety precautions should be taken when conducting the investigation.
- Measurements and observations should be recorded accurately in the appropriate table, chart, or graph.

**It is not essential for students to** design or conduct an experiment that includes a controlled set-up (7-1.3).

**Assessment Guidelines:**
One objective of this indicator is to *plan* controlled scientific investigations, manipulating one variable at a time; therefore, the primary focus of assessment should be to design the procedures for completing a scientific investigation where one variable is manipulated. However, appropriate assessments should also require students to *recognize* steps appropriate for conducting a controlled investigation; *detect* inappropriate steps in a given investigation; or *organize* the results of the investigation in tables or charts.

Another objective of this indicator is to *conduct* controlled scientific investigations, manipulating one variable at a time; therefore, the primary focus of assessment should be to carry out the procedures for completing a scientific investigation where one variable is manipulated. However, appropriate assessments should also require students to *summarize* the steps of a controlled investigation; *use* appropriate tools and safety precautions when conducting the investigation; *identify* appropriate tools for an investigation; *recognize* measurements and observations that are accurate and inaccurate in an investigation.

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**5-1.4 Use appropriate tools and instruments (including a timing device and a 10x magnifier) safely and accurately when conducting a controlled scientific investigation.**
**Taxonomy Level:** 3.2-C Apply Procedural Knowledge

**Previous/future knowledge:** In previous grades, students used magnifiers and eyedroppers (K-1.2), rulers (1-1.2), thermometers, rain gauges, balances, and measuring cups (2-1.2), beakers, meter tapes and sticks, forceps/tweezers, tuning forks, graduated cylinders, and graduated syringes (3-1.5), and a compass, an anemometer, mirrors, and a prism (4-1.2) safely, accurately, and appropriately. In future grades, students will continue to use these tools, when appropriate, as well as use new tools when collecting scientific data. A complete list of tools can be found in Appendix A of the Academic Standards.

**It is essential for students to** know that different instruments or tools are needed to collect different kinds of data.

- A *timing device* is an instrument used to measure time.
  - An example of a timing device is a stop watch or clock with a second hand.
  - Time is measured in seconds (s), minutes (min), hours (hr), and days.
- A *10x magnifier* is a tool that is used to enlarge objects or see details.
  - Objects seen through a 10x magnifier look ten times larger than they do with the unaided eye.

**It is essential for students to** use care when handling these tools when gathering data.

- Care should be taken not to break or drop the timing device or magnifier.

**It is also essential for students to** use tools from previous grade levels that are appropriate to the content of this grade level such as eyedroppers, magnifiers, rulers (measuring to centimeters or millimeters), pan balances (measuring in grams), thermometers (measuring in $^{o}$F and $^{o}$C), beakers (measuring liters or milliliters), forceps/tweezers, graduated cylinders (measuring in milliliters), graduated syringes (measuring in milliliters), meter sticks and meter tapes (measuring in meters, centimeters, or millimeters), or compasses to gather data. Other units of measurement that students should be familiar with are kilograms (mass) or kilometers (distance).

NOTE TO TEACHER: See information in previous grades regarding how to use each tool.
All temperature readings during investigations will be taken using the Celsius scale unless the data refers to weather when the Fahrenheit scale is used.

**It is not essential for students to** know how to use spring scales or a more complex magnifier such as a microscope. Tools from previous grades that are not appropriate to the content of this grade level are not essential; however, these terms may be used as distracters (incorrect answer options) for assessment, for example measuring cups, rain gauges, tuning forks, anemometers, mirrors (plane/flat), or prisms. Students do not need to convert measurements from English to metric or metric to English.

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**Assessment Guidelines:**
The objective of this indicator is to *use* tools safely, accurately, and appropriately when gathering data; therefore, the primary focus of assessment should be to apply correct procedures to the use of a timing device, a 10x magnifier, and other tools essential to the grade level that would be needed to conduct a science investigation. However, appropriate assessments should also require students to *identify* appropriate uses for a timing device, or a 10x magnifier; *illustrate* the appropriate tool for an investigation using pictures, diagrams, or words; *recall* how to accurately determine the measurement from the tool; or *recognize* ways to use science tools safely, accurately, and appropriately.

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**5-1.5 Construct a line graph from recorded data with correct placement of independent (manipulated) and dependent (responding) variables.**
**Taxonomy Level:** 6.3-C Create Procedural Knowledge

**Previous/Future knowledge**: In 4th grade, students recognized the correct placement of variables on a line graph (4-1.5) and constructed and interpreted diagrams, tables, and graphs made from recorded measurements and observations (4-1.6). In 7th grade (7-1.5), students will explain the relationships between independent and dependent variables in a controlled scientific investigation through the use of appropriate graphs, tables, and charts.

**It is essential for students to** know that line graphs are used to represent data that has been collected over a determined amount of time (for example, change in fish population in a week). Once the data has been collected and organized in an appropriate data table, a graph can be constructed. To construct a line graph, the following steps should be taken:

- Draw a horizontal line (x-axis) and a vertical line (y-axis) that meet at a right angle.
- Identify the independent (manipulated) variable and the dependent (responding) variable from the data.
    - The independent (manipulated) variable is written on the x-axis.
    - The dependent (responding) variable is written on the y-axis.
    - Include appropriate units of measurement for each variable.
- Look at the range of data (lowest and highest) to determine the *intervals* or *increments* (numbers on the axes) of the x-axis and the y-axis.
    - The increments do not need to be the same for both the x-axis and the y-axis, but should be consistent on either axis.
    - Label the point at the right angle as zero (0).
- Plot the data on the graph as matched pairs. For example, every independent (manipulated) variable number will have a corresponding dependent (responding) variable number.
- Connect the points on the line graph.
- Write an appropriate title for the graph that contains the names of both variables.

NOTE TO TEACHER: A mnemonic device that can be used to teach the appropriate locations of the variables on a graph is DRY MIX.

- DRY represents Dependent-Responding-Y-axis.
- MIX represents Manipulated-Independent-X-axis.

**It is not essential for students to** construct circle graphs.

**Assessment Guidelines:**
The objective of this indicator is to *construct* a line graph from recorded data with correct placement of independent (manipulated) and dependent (responding) variables; therefore, the primary focus of assessment should be to create a line graph with the proper placement of the variables and data from the investigation. However, appropriate assessments should also require students to *identify* the correct placement of variables on line graphs; *identify* the parts of a line graph; *recognize* appropriate increments for a line graph of recorded data; *recognize* appropriate title for recorded data; *match* appropriate title to a given line graph; *exemplify* appropriate line graphs from recorded data; or *compare* line graphs with recorded data.

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**5-1.6 Evaluate results of an investigation to formulate a valid conclusion based on evidence and communicate the findings of the evaluation in oral or written form.**
**Taxonomy Level:** 5.2-B Evaluate Conceptual Knowledge

**Previous/Future knowledge**: In 2nd grade (2-1.3), students represented and communicated simple data and explanations through drawings, tables, pictographs, bar graphs, and oral and written language. In 3rd grade (3-1.7), students explained why similar investigations might produce different results. In 4th grade (4-1.6), students constructed and interpreted diagrams, tables, and graphs made from recorded measurements and observations. In 7th grade, students will generate questions that can be answered through scientific investigation (7-1.2) and will critique a conclusion drawn from a scientific investigation (7-1.6). In 8th grade, students will construct explanations and conclusions from interpretations of data obtained during a controlled scientific investigation (8-1.3) and will generate questions for further study on the basis of prior investigations (8-1.4).

**It is essential for students to** know that data from an investigation can be organized in tables and graphs so that a valid conclusion can be drawn.

- A *valid conclusion* is an explanation based on observations and collected data that states the relationship between the independent (manipulated) and dependent (responding) variables.
- Inferences are sometimes needed to help form a valid conclusion.
  - An *inference* is an explanation or interpretation of an observation based on prior experiences or supported by observations made in the investigation.
- A conclusion statement should include a comparison of the results of the investigation to the hypothesis.
- Communicating the results of an experiment (in diagrams or graphs) allows others to evaluate and understand the investigation.
- The conclusion can be presented in written form and/or orally.

**It is not essential for students to** generate a new question or new hypothesis from the results of an investigation.

**Assessment Guidelines:**
One objective of this indicator is to *evaluate* results of an investigation to formulate a valid conclusion based on evidence and communicate the findings of the evaluation in oral or written form; therefore, the primary focus of assessment should be to make judgments about an investigation based on the results. However, appropriate assessments should also require students to *recognize* a valid conclusion for a given investigation; *compare* data recorded with the steps in the investigation; *identify* and *exemplify* observations and inferences used to formulate a valid conclusion; *compare* the conclusion with the hypothesis; *explain* the results of an investigation; or *identify* graphs which correctly represent given data.

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**5-1.7 Use a simple technological design process to develop a solution or a product, communicating the design by using descriptions, models, and drawings.**
**Taxonomy Level:**

**Previous/Future knowledge**: This is the first time that the technological design process has been introduced. In 6th grade (6-1.4), students will use a technological design process to plan and produce a solution to a problem or a product (including identifying a problem, designing a solution or a product, implementing the design, and evaluating the solution or the product). In high school Physical Science (PS-1.8), students will compare the processes of scientific investigation and technological design.

**It is essential for students to** know that *technology* is any tool or process designed to help society in some way. Technology applies scientific knowledge in order to develop a solution to a problem or create a product to help meet human needs. Technology is usually developed because there is a need or a problem that needs to be solved. *Technological design* is the process of using scientific knowledge and processes to develop technology (such as solutions to a problem or a new or improved product). Steps in the technological design process include:

- *Identifying a problem or need*
    - Research and gather information on what is already known about the problem or need
- *Designing a solution or a product*
    - Generate ideas on possible solutions or products
- *Implementing the design*
    - Build and test a solution or a product
- *Evaluating the solution or the product*
    - Determine if the solution or product solved the problem

The steps of the design can be communicated using descriptions, models, and drawings.

- A *scientific model* is an idea that allows us to create explanations of how the something may work. Models can be physical or mental.

NOTE TO TEACHER: Students in 5th grade need to know the steps used in a simple technological design, but do not have to carry out the steps to create the product or solution. However, to conceptualize this process, the implementation of the steps would be helpful.

**It is not essential for students to** compare the processes of a controlled scientific investigation and the technological design process or evaluate a technological design or product on the basis of designated criteria (including cost, time, and materials).

**Assessment Guidelines:**
The objective of this indicator is to *use* a simple technological design process to develop a solution or a product, communicating the design by using descriptions, models, and drawings; therefore, the primary focus of assessment should be to apply the procedures for a simple technological design process as listed in the indicator. However, appropriate assessments should also require students to *illustrate* the design process through words, pictures, or diagrams; *summarize* the process of technological design; *identify* the steps of technological design; or *match* a specific solution or product to a specific need or problem.

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**5-1.8 Use appropriate safety procedures when conducting investigations.**
**Taxonomy Level:** 3.2-C Apply Procedural Knowledge

**Previous/Future knowledge:** In all grades students use appropriate safety procedures when conducting investigations that are appropriate to their grade, tools, and types of investigations.

**It is essential for students to** know that care should be taken when conducting a science investigation to make sure that everyone stays safe.

Safety procedures to use when conducting simple science investigations may be

- Always wear appropriate safety equipment such as goggles or an apron when conducting an investigation.
- Be careful with sharp objects and glass. Only the teacher should clean up broken glass.
- Do not put anything in the mouth unless instructed by the teacher.
- Follow all directions for completing the science investigation.
- Follow proper handling of animals and plants in the classroom.
- Keep the workplace neat. Clean up when the investigation is completed.
- Practice all of the safety procedures associated with the activities or investigations conducted.
- Tell the teacher about accidents or spills right away.
- Use caution when mixing solutions.
- Use caution when working with heat sources and heated objects.
- Wash hands after each activity.

**It is essential for students to** use tools safely and accurately, including a timing device and a 10x magnifier, when conducting an investigation.

NOTE TO TEACHER (safety while working with students):

- Teacher materials have lists of "Safety Procedures" appropriate for the suggested activities. Students should be able to describe and practice all of the safety procedures associated with the activities they conduct.
- Most simple investigations will not have any risks, as long as proper safety procedures are followed. Proper planning will help identify any potential risks and therefore eliminate any chance for student injury or harm.
- Teachers should review the safety procedures before doing an activity.
- Lab safety rules may be posted in the classroom and/or laboratory where students can view them. Students should be expected to follow these rules.
- A lab safety contract is recommended to notify parents/guardians that classroom science investigations will be hands-on and proper safety procedures will be expected. These contracts should be signed by the student and the parents or guardians and kept on file to protect the student, teacher, school, and school district.
- In the event of a laboratory safety violation or accident, documentation in the form of a written report should be generated. The report should be dated, kept on file, include a signed witness statement (if possible) and be submitted to an administrator.
- Materials Safety Data Sheets (MSDS) will be found in kits if necessary.
- For further training in safety guidelines, you can obtain the SC Lab Safety CD or see the Lab Safety flip-chart (CD with training or flip-chart available from the SC Department of Education).

**Scientific Inquiry**

**5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.**

**It is not essential for students to** go beyond safety procedures appropriate to the kinds of investigations that are conducted in a fifth grade classroom.

**Assessment Guidelines:**
The objective of this indicator is to *use* appropriate safety procedures when conducting investigations**;** therefore, the primary focus of assessment should be to apply correct procedures that would be needed to conduct a science investigation. However, appropriate assessments should also require students to *identify* safety procedures that are needed while conducting an investigation; or *recognize* when safety procedures are being used.